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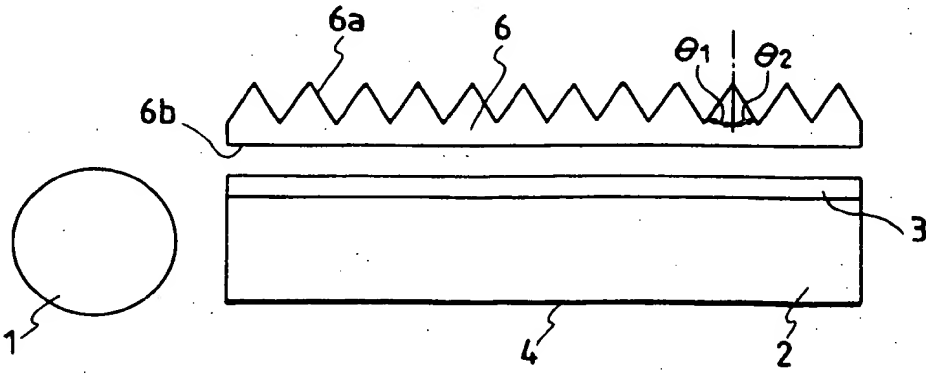
(54) **Surface light source device.**

(57) A surface light source device comprising at least one light source (1), a transparent panel (2), a diffusing panel (3) and a reflecting surface (4). This surface light source device is configured so that brightness is enhanced in a direction perpendicular to the diffusing panel (3) by disposing, on the side of a front surface of the transparent panel (2), a transparent sheet (6) which has protrusions (6a) having a saw-tooth-like sectional shape formed on one surface thereof.

FIG. 4



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Background of the Invention

a) Field of the invention:

The present invention relates to a surface light source device which is to be used as a back light for liquid crystral display units, and more specifically to a surface light source device which uses a transparent panel member or a reflecting panel member.

b) Description of the prior art:

The conventional surface light source device which uses a transparent panel has a composition as illustrated in Fig. 1. In this drawing, the reference numeral 1 represents a light source, the reference numeral 2 designates a transparent panel, the reference numeral 3 denotes a diffusing panel and the reference numeral 4 represents a reflecting surface. The light source 1 used in this surface light source device is a linear light source which is, for example, a cold cathod ray tube and extends in the direction perpendicular to the paper surface. The transparent panel 2 is made of a glass material or a transparent plastic material. As a material for the transparent panel 1, it is general to select a plastic material such as acrylic resin which is light in weight thereof and available at a low cost. The transparent panel 2 has a form of a plane parallel plate which has thickness of t and a rectangular or square surface. A light beam emitted from the linear light source 1 enters through an end surface of incidence 2a into the transparent panel 2 and travels through the transparent panel 2 as represented by a ray 10 in Fig. 1. During this travel, portions of the light beam emerge from the transparent panel 2 (upward in Fig. 1) and pass through the diffusing panel 3 to produce diffused rays. The surface light source device produces the diffused rays which are diverging from various points on the surface of the diffusing panel (the upper surface shown in Fig. 1) as described above. The ray 10 shown in Fig. 1 is diverged from a point A on the diffusing panel 3. In a case where the diffusing panel 3 should not be used, a ray which travels in a direction having an angle of γ indicated by an arrow has the highest brightness. The angle γ has a value which is different dependently on refractive indices of materials selected for the transparent panel 2. Experiments effected by selecting an acrylic resin having a refractive index of 1.49 indicated results that the angle γ has a value of approximately 75°. When the diffusing panel 3 is placed over the transparent panel 2 so that rays having passed through the diffusing panel 3 are diffused, deflection of the rays is corrected a little due to the diffusion of the rays, but brightness in the direction perpendicular to the transparent panel is not enhanced so remarkably. When a liquid crystal display panel, for example, is illuminated by using the surface light source device which uses the diffusing panel 3 placed over the transparent panel 2, brightness of the diffused rays is low in a direction for observation, i.e., in a direction having the angle $\gamma = 0°$, whereas brightness of the diffused rays is the highest in an oblique direction having an angle $\gamma \fallingdotseq 75°$ which is deviated from the direction for observation. Accordingly, an observer of the liquid crystal display panel is undesirably obliged to observe an image which is relatively dark.

As another conventional example of the surface light source device which uses the transparent panel, there is also known the surface light source device illustrated in Fig. 2. In this conventional example, two linear light sources 1, 1 are disposed beside both end surfaces of a transparent panel 5. The two light sources 1, 1 are adopted for obtaining a surface light source device which can provide diffused rays having higher brightness.

Further, the transparent panel 5 of the surface light source device illustrated in Fig. 2 has a thinned central portion (the portion farthest from the light sources disposed on the right and left sides) and a top surface 5b which is inclined.

The surface light source device illustrated in Fig. 2 is configured so that light beams emitted from the right side and left side light sources 1, 1 enter through end surfaces of incidence 7a, 7a of the transparent panel 7, and emerge out of a diffusing panel 3 so as to produce diffused rays. In case of the surface light source device which uses the inclined top surface 7b, rays emerging from the transparent panel 7, for example rays 10 and 11, have the highest brightness at an inclination angle which is a little smaller, or the angle γ has a value of approximately 60°. However, the surface light source device illustrated in Fig. 2 cannot provide the diffused rays which have sufficient brightness in the direction for observation and obliges to observe relatively dark images.

In addition, there are known transparent panels each of which has thickness progressively thinned along a curve from an end surface of incidence as well as those each of which has thickness progressively thinned along curves from a plurality of end surfaces of incidence. There are also known transparent panels each of which is combined with a plurality of light sources and has uniform thickness.

Summary of the Invention

A primary object of the present invention is to provide a surface light source device which comprises at least one light source, a transparent panel

having at least one end surface of incidence disposed in the vicinity of the light source, two diffusing panels disposed on a top surface of the transparent panel with a space reserved the diffusing panels, and a reflecting surface disposed on a rear surface of the transparent panel.

Another object of the present invention is to provide a surface light source device which comprises at least one light source, a transparent panel having at least one end surface of incidence disposed in the vicinity of the light source, a diffusing panel disposed on a top surface of the transparent panel, a transparent sheet having, on one surface thereof, protrusions which have a saw-tooth-like sectional shape, and a reflecting surface disposed on a rear surface of the transparent panel.

The surface light source device according to the present invention enhances brightness in a direction perpendicular to the diffusing panels or panel by using the two diffusing panels or the transparent sheet having the surface on which saw-tooth-like protrusions are formed as described above.

The transparent sheet may have a form which has a large number of very small conical or pyramidal protrusions formed on one surface. Further, tips or vertices of the conical or pyramidal protrusions may be rounded.

Formed on one surface of the transparent sheet are rows of the protrusions which have the saw-tooth-like sectional shape.

In a particular case where the surface light source device according to the present invention is to be used as a back light for a liquid crystal display panel, it is preferable, for preventing stripe patterns from appearing on a display panel of the liquid crystal display unit, to configure the transparent sheet so that the rows of the top lines of the protrusions are oblique relative to bus lines or sides of a frame of the display panel.

Further, in the case where the transparent sheet has a large number of the conical or pyramidal protrusions, it is desirable that rows of the protrusions are oblique relative to the bus lines or the sides of the frame of the liquid crystal display panel as in the case described above.

Brief Description of the Drawings

Fig. 1 shows a sectional view illustrating a composition of the conventional surface light source device;

Fig. 2 shows a sectional view illustrating a composition of a different type of the conventional surface light source device;

Fig. 3 through Fig. 8 show sectional views illustrating compositions of first through sixth embodiments of the surface light source device according to the present invention;

Fig. 9 shows a perspective view of a transparent panel which is tinned at a central portion thereof for use in a surface light source device equipped with four light sources disposed besides the four sides of the transparent panel;

Fig. 10 shows a plan view of a transparent panel which is to be used in the surface light source device according to the present invention;

Fig. 11 shows a perspective view of the transparent sheet shown in Fig. 10.

Fig. 12 shows a schematic sectional view illustrating an overall configuration of a combination liquid crystal display panel and the surface light source device according to the present invention used as a back light for the liquid crystal display panel;

Fig. 13 shows a plan view illustrating the transparent sheet which has oblique rows of the top lines of protrusions which has a saw-tooth-like sectional shape;

Fig. 14 shows a perspective view of the transparent sheet which has oblique rows of vertices of conical protrusions;

Fig. 15 shows a sectional view illustrating an example of a surface light source device wherein the transparent panel shown in Fig. 12 is utilized in a surface light source device of the type using a reflecting panel; and

Fig. 16 shows a sectional view of a part of another transparent sheet.

Detailed Description of the Preferred Embodiments

The first embodiment of the surface light source device according to the present invention is illustrated in Fig. 3, wherein the reference numeral 1 represents a light source, the reference numeral 2 designates a transparent panel, the reference numeral 3 denotes a diffusing panel and the reference numeral 4 represents a reflecting panel. The first embodiment of the presnet invention has a composition which is substantially the same as that of the conventional surface light source device illustrated in Fig. 1. The reference numeral 5 represents another diffusing panel which is adopted for enhancing brightness or luminance in the direction for observation (the direction prependicular to the diffusing panels shown in Fig. 3). In other words, the diffusing panel 5 serves for enhancing brightness in the direction for observation by further diffusing rays (or controlling directions of rays) travelling in the direction at the angle of γ shown in Fig. 1 so that a portion of the ray is directed upward (in the direction for observation).

Experiments which were effected for comparing the conventional surface light source device shown in Fig. 1 with the first embodiment of the

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parent sheets in layers. In that case, it is preferable to incline the tansparent sheet the nearest to the liquid crystal display panel relative to bus line or sides of a frame of the liquid crystal display panel (for example, 45°) The other transparent sheets don't have to be oblique.

important aspects of the described invention are as follows:

A surface light source device comprising at least one light source, a transparent panel, a diffusing panel and a reflecting surface. This surface light source device is configured so that brightness is enhanced in a direction perpendicular to the diffusing panel by disposing, on the side of a front surface of the transparent panel, a transparent sheet which has protrusions having a saw-tooth-like sectional shape formed on one surface thereof.

Claims

1. A surface light source device comprising: a transparent panel which is made of a transparent material, rectangular in a surfacial shape therof and uniform in thickness thereof; at least one linear light source which is disposed in the vicinity of at least one side of said tansparent panel; a diffusing panel and a transparent sheet which has protrusions having saw-tooth-like sectional shape formed in rows nearly parallel with one another on one surface thereof, these members being disposed with a space reserved therebetween on the side of a front surface of said transparent panel; and reflecting surface disposed on a rear surface of said transparent panel, wherein top lines of said protrusion which have the saw-tooth-like sectional shape and are formed on said transparent sheet are aranged in rows obliquely directed relative to sides of said transparent panel.

2. A surface light source device according to Claim 1 wherein said transparent sheet is disposed between said transparent panel and said diffusing panel.

3. A surface light source device according to Claim 1 wherein said light source and another light source are disposed beside two sides of asid transparent panel which are opposite to each other, and said transparent panel has thickness which is reduced as portions of said panel are farther from said light sources or a concave surface.

4. A surface light source device according to Claim 1 wherein said transparent panel has a square surface.

5. A surface light source device according to Claim 4 wherein said light sources and three other light sources are disposed beside four sides of said thrasparent panel and said transparent panel has thickness whihc is reduced as portions of said transparent panel are farther from said light sources or a concave surface.

6. A surface light source device according to Claim 4 wherein said light sources and another light source are disposed beside two sides of said tranparent panel and said transparent panel has thickness which is reduced as portions of said transparent panel are farther from said light sources or a concave surface.

7. A surface light source device according to Claim 6 wherein said transparent sheet is disposed in contact with the surface of said transparent panel.

8. A surface light source device according to Claim 1, 2, 3, 4, 5, 6 or 7 wherein said protrusions formed on said transparent sheet have curved tips.

9. A surface light source device comprising: a transparent panel which is made of a transparent material, rectangular in a surfacial shape thereof and uniform in thickness thereof; at least one light source disposed beside at least one side of said tansparent panel; a diffusing panel disposed on the side of a front surface of said tranaparent panel; and a reflecting surface disposd on the side of a rear surface of said transparent panel; wherein protrusions having a saw-tooth-like sectional shape are formed on the front surface of said transparent panel, said protrusions have curved tips.

10. A surface light source device comprising: a transparent panel which is made of a transparent material, rectangular in a surfacial shape thereof and uniform in thickness thereof; at least one light sources disposed in the vicinity of at least one side of said transparent panel; a diffusing plate and a transparent sheet having a large number of minute protrusions formed on a surface thereof which are disposed on the side of a front surface of said transparent panel; and a reflecting surface disposed on the side of a rear surface of said transparent panel, said minute protrusions having curved tips.

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11. A surface light source device according to Claim 10 wherein said transparent sheet is disposed between said tansparent panel and said diffusing panel.

12. A surface light source device according to Claim 10 or 11 wherein said protrusions formed on said transparent panel are conical.

13. A surface light source device according to Claim 10 or 11 wherein said protrusions formed on said transparent sheet are pyramidal.

14. A surface light source device according to Claim 10, 11, 12 or 13 wherein said protrusions formed on said transparent sheet are arranged in rows obliquely directed relative to the sides of said transparent panel.

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FIG. 1

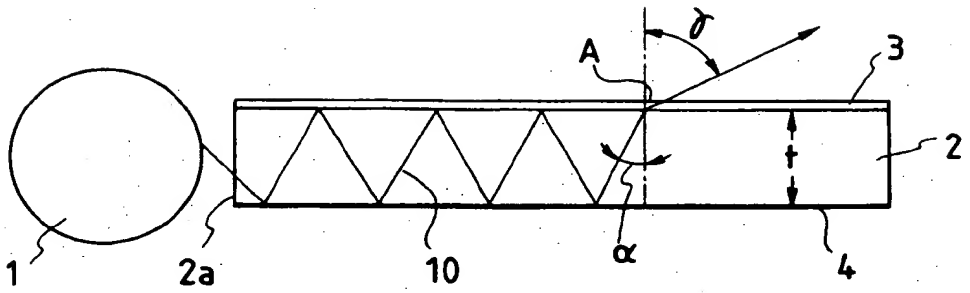

FIG. 2

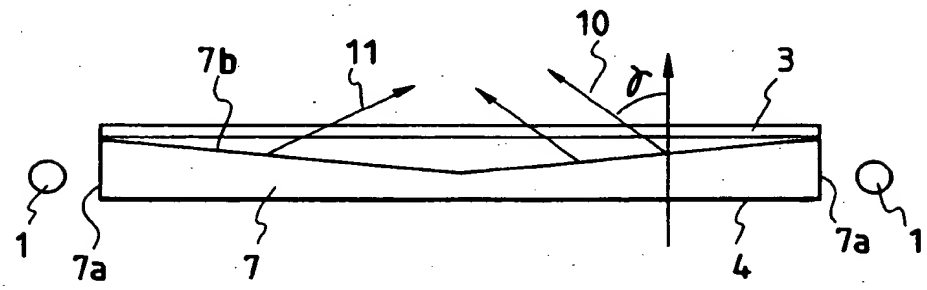

FIG. 3

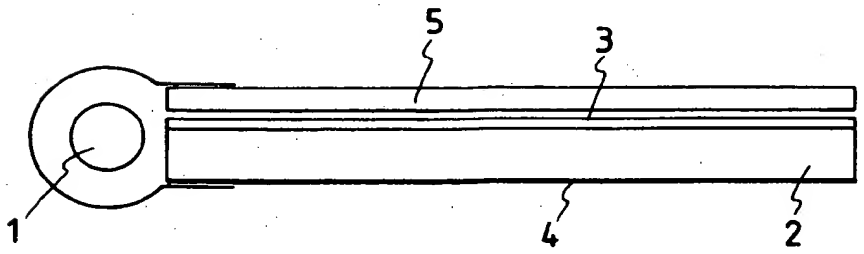

FIG. 4

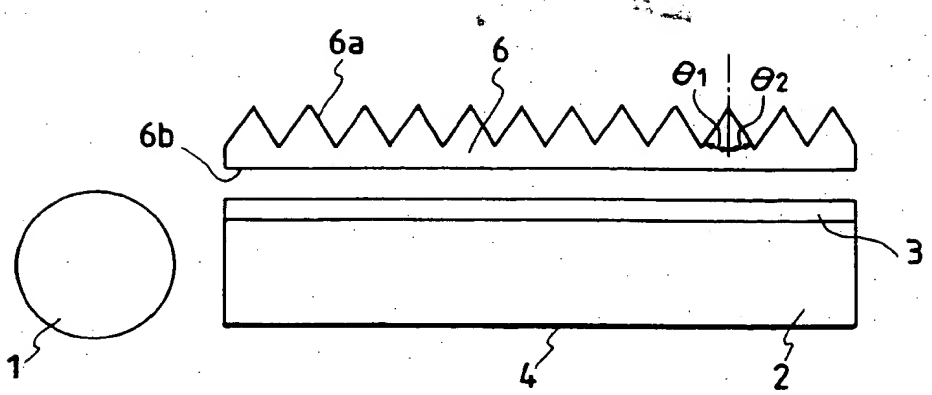

FIG. 5

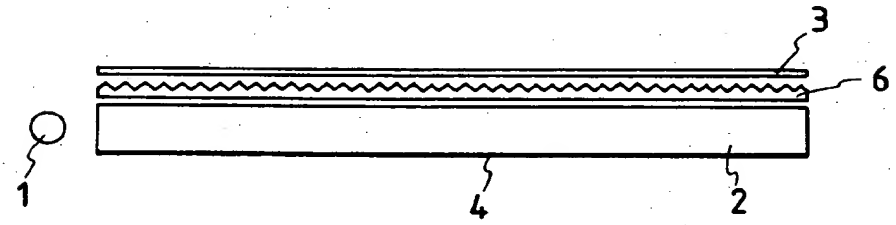

FIG. 6

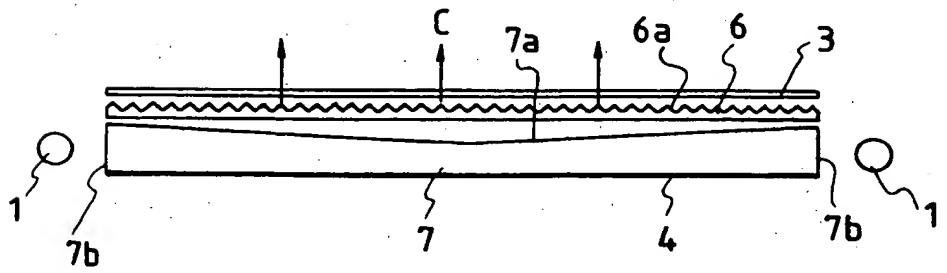

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FIG. 7

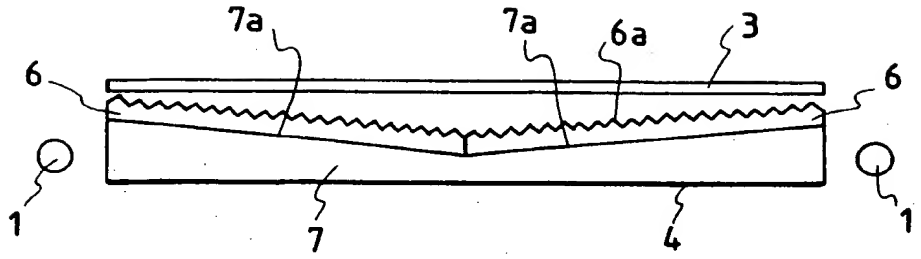


FIG. 8

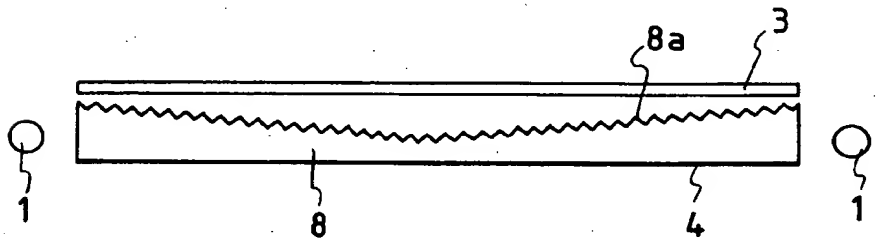


FIG. 9

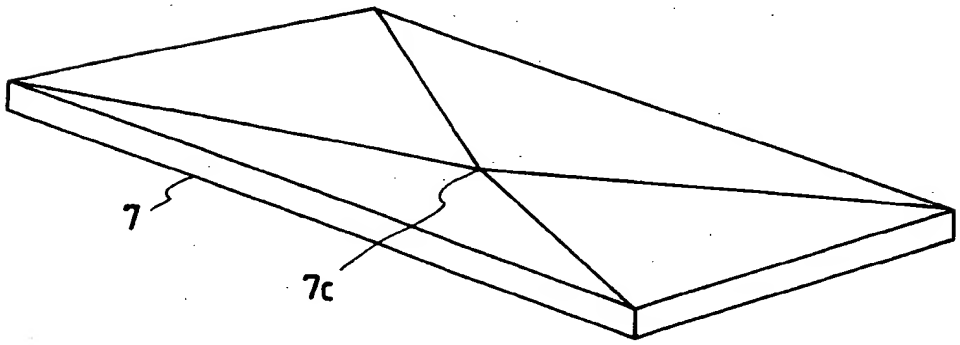


FIG. 10

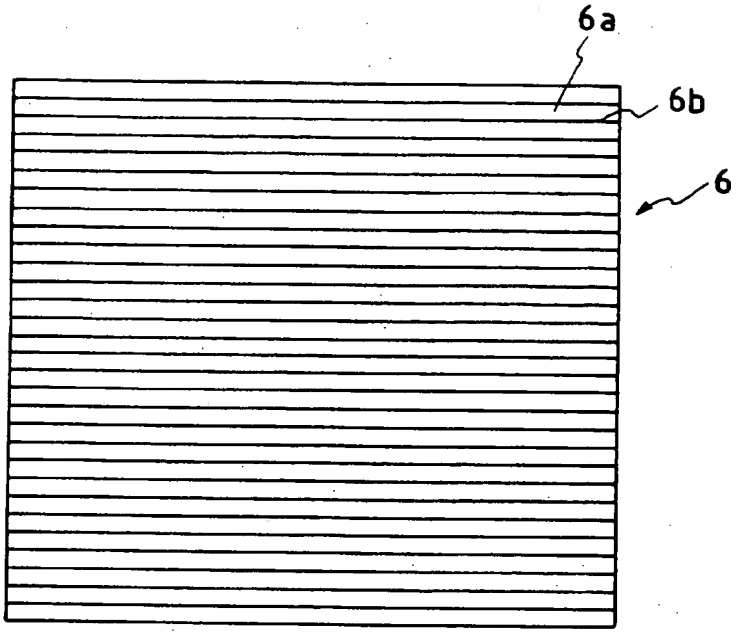


FIG. 11

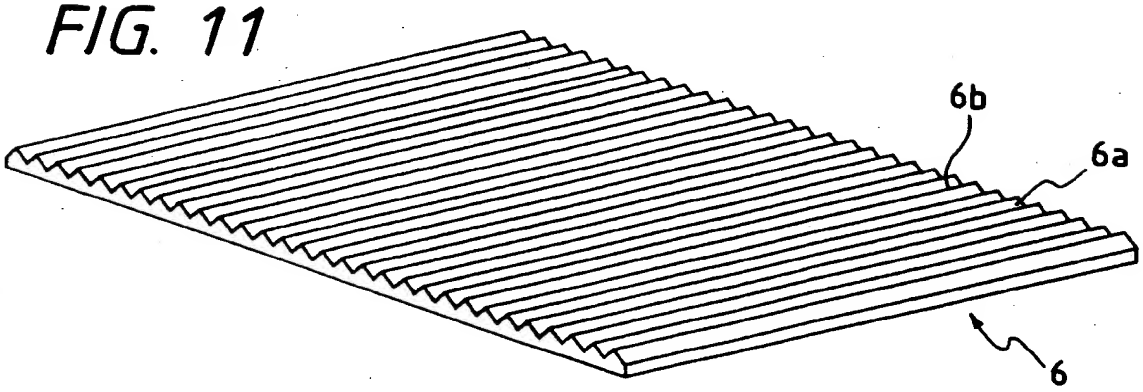


FIG. 12

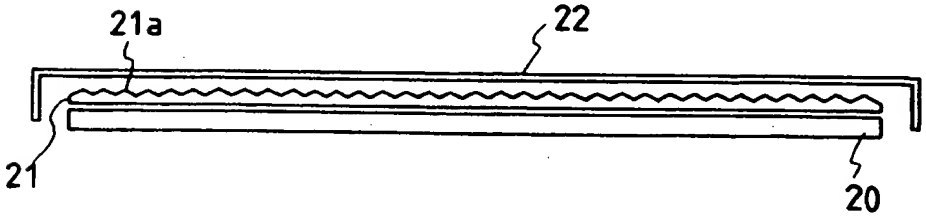


FIG. 13

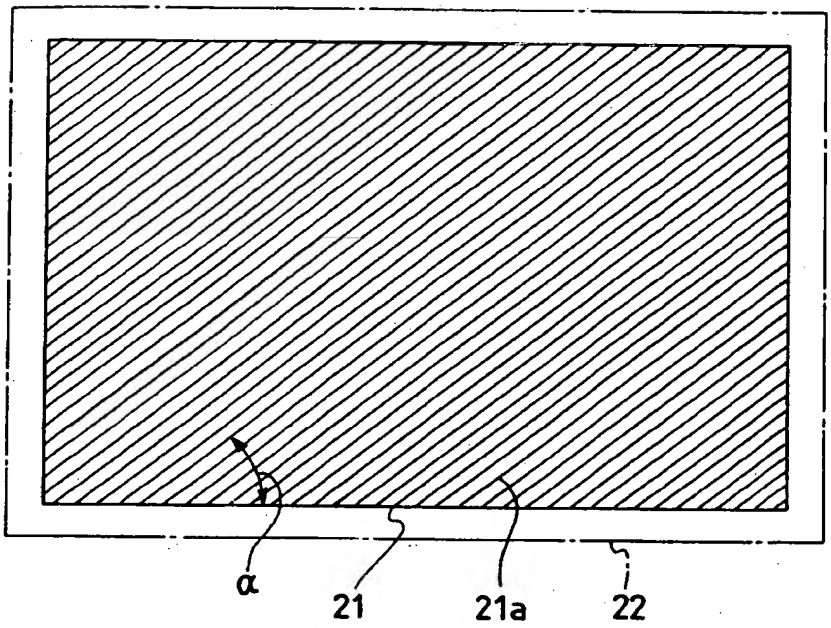


FIG. 14

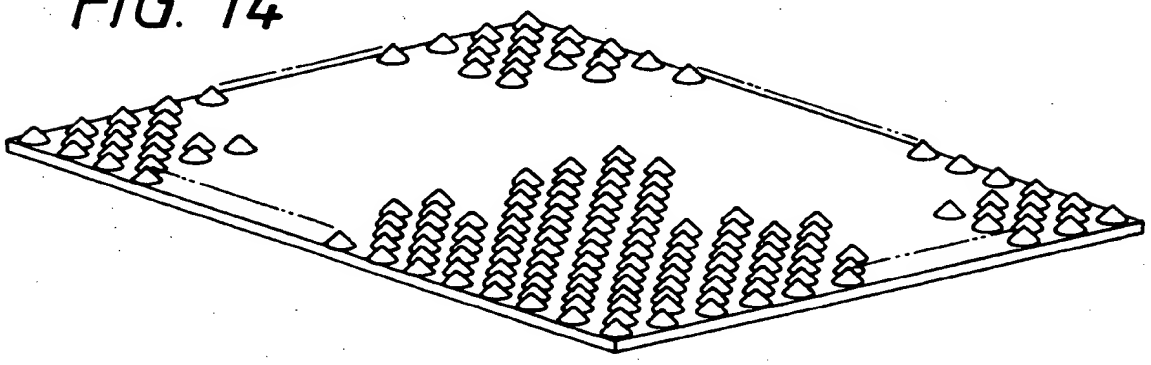


FIG. 15

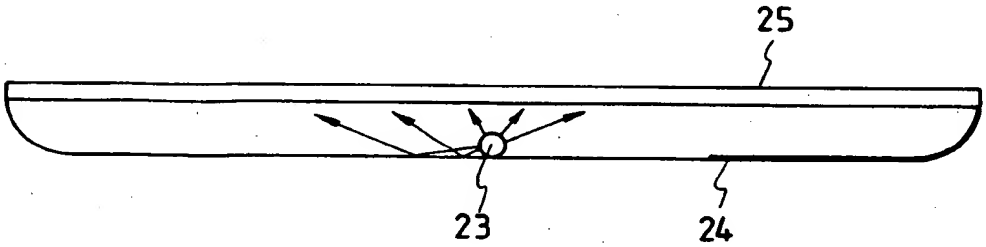
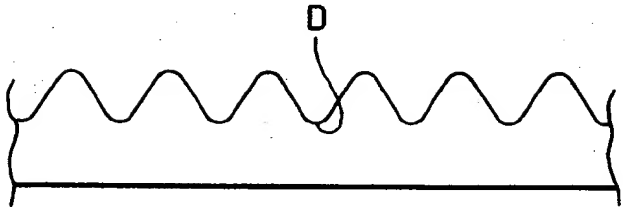


FIG. 16



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EUROPEAN SEARCH REPORT

Application Number EP 92115346.6

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	FR - A - 2 576 441 (BLANCHET) * Fig. 1; abstract *	1	G 09 F 13/16 G 09 F 13/04
A		2,3,4, 6,7,9, 10,11	
Y	GB - A - 315 743 (BURNS) * Fig. 2,3,4 *	1	
A		9,10, 14	
A	GB - A - 325 957 (TAYLOR) * Fig. 1,2,3 *	1,8,9, 10	
A	EP - A - 0 392 863 (FUJITSU LTD.) * Fig. 1,4 *	1,3,6, 9,10	
A	EP - A - 0 395 344 (MITSUBISHI RAYON CO. LTD.) * Fig. 1,2,3,4,15,19,24,27 *	1,9,10	TECHNICAL FIELDS SEARCHED (Int. Cl.5) G 09 F 13/00 G 09 F 9/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	06-11-1992	BRÄUER

CATEGORY OF CITED DOCUMENTS

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